

Floods Risk Assessment

This plan is an update of the 2004 City of Redmond Hazard Mitigation Plan (HMP). Although it is an update, this document has been redesigned so that it looks, feels, and reads differently than the original. This is due to several factors: new hazard information has become available that drives new definitions of risk, the City has matured and new capabilities are now available, and the new format will allow readers to more easily understand the content. In addition, the 2004 HMP included several action items that have been completed, creating an opportunity for developing new mitigation strategies.

6.1 Identify Flood Hazards

A flood is a temporary inundation with water of normally dry land⁵⁹. Flooding can be caused by a body of water such as a river overflowing its banks or by a rapid accumulation of surface-water runoff.⁶⁰ Built structures can become flooded by groundwater seepage when the water table rises or the surrounding ground becomes saturated.

Flood damage can range from minimal localized damage to complete destruction of built structures. The velocity and volume of water present a risk in a flood event. Additionally, contaminants in the water pose a secondary threat.⁶¹ Flood water may contain gasoline or other hazardous chemicals as well as debris. Consequently, flooding can present both immediate concerns and secondary effects.

FEMA requires municipalities to plan for the 100-year flood. The 100-year floodplain is an area that has a 1% chance of flooding in any given year.⁶²

Climate Change Impact

Research conducted by the International Panel on Climate Change suggests that within any given future year, wetter winters with increasing rainfall and rain intensity can be expected.⁶³ In Redmond, this will lead to a higher frequency of flood events as well as the potential raising of the water level. Anticipated climate changes suggest that Redmond will experience more flooding from groundwater seepage and more frequent flooding along the Bear Creek and Sammamish River trails and Lake Sammamish.

59 Janet Thingpen, *Stream Processes: A Guide to Living in Harmony with Streams* (New York: Chemung County Soil and Water Conservation District, 2006), 68.

60 National Flood Insurance Program, "Flooding and Risks: What Causes Flooding," Federal Emergency Management Agency, http://www.floodsmart.gov/floodsmart/pages/flooding_flood_risk/what_causes_flooding.jsp.

61 Federal Emergency Management Agency and American Red Cross, *Repairing Your Flooded Home*, (Washington DC: FEMA Publications, 1992), 15.

62 Susan Bolton, JL Clark, Bob Freitag, and Frank Westurland, *Getting Wet: Benefiting from Flooding in the 21st Century*, (Draft, 2009), 9.

63 Climate Impacts Group: Joint Institute for the Study of the Atmosphere and Ocean, "Seasonal to Interannual Forecasts; Extreme Weather: Background," University of Washington, <http://cses.washington.edu/cig/fpt/exbackground.shtml>.

6.2 Profiling Flood Hazard Events

A. Location

The Sammamish River, Bear Creek, Evans Creek, and parts of Lake Sammamish are located within the City limits of Redmond. A large portion of Redmond's downtown district lies within the 100-year Sammamish River floodplain. **Map 16, City of Redmond 100-Year Floodplain and Chronically Flooded Areas**, shows the location of the floodplain and the waterways. Swelling or over-topping of the Lake Sammamish will flood lakeside homes and docks. The high water table, with an estimated average depth of 25 feet, increases the likelihood of seepage flooding.

Areas regularly flooded include parts of the Sammamish River and Bear Creek trail systems, portions of the City's Municipal Campus, condominium developments along Lake Sammamish, and an area near Bear Creek's Friendly Village Mobile Home Park. **Map 16, City of Redmond 100-Year Floodplain and Chronically Flooded Areas**, illustrates areas of chronic flooding in Redmond and identifies flood-related capital improvement projects (CIPs).

The majority of structural flooding in Redmond occurs in buildings with crawl spaces, basements, subsurface parking or other underground development. The swelling of the Sammamish River causes the water table to rise, which then seeps into underground spaces. In January 2009, the Lake Sammamish condominium owners and the Friendly Village mobile home owners used sandbags to block water from entering their structures.

The City of Redmond is a member of the National Flood Insurance Program. Residents living in the 100-year floodplain are required to have flood insurance. There have only been five claims within Redmond's City limits through FEMA's National Flood Insurance Program (NFIP). The locations of the claims are shown in **Map 17, City of Redmond NFIP Claims and Holders**. Only one of the five claims lies within the 100-year floodplain. The remaining claims were the result of groundwater seepage or drainage problems.

B. Timing and Duration

Weather forecasts and the close monitoring of local water systems normally provide substantial warning prior to flooding. 50% of Redmond's annual precipitation typically occurs in the four-month period from October through January and 75% occurs in the six-month period from October through March.⁶⁴ Flash floods or floods caused by a collapse of land along a shoreline have a significantly shorter warning time.

Groundwater seepage and stormwater runoff cause most of the flooding in Redmond. Since the wet season is the typical time for these issues, the City usually has adequate time to prepare. Also, much of the City is far enough away from the Sammamish

⁶⁴ King County Department of Natural Resources and Parks, Water and Land Resources Division, "2006 King County Flood Hazard Management Plan," King County River and Floodplain Management Program.

River that groundwater level may take up to six hours⁶⁵ to rise in response to a Sammamish River flood event. Knowledge gained from past occurrences can also help localized areas of flooding prepare for future events.

The duration of a flooding event may be limited to a few hours or may extend for several days or even weeks.

C. Severity

Though frequent, flood events in Redmond are not particularly severe. According to the FEMA 100-year flood depth grids, the majority of the floodplain will become inundated by only one foot of water. Two small portions of the floodplain near the convergence of Bear Creek and the Sammamish River are susceptible to inundation between two and three feet (see **Map 18, City of Redmond Buildings Vulnerable to Flooding**). Since the 100-year floodplain is large, deep floodwaters are not a concern. Flood damage costs in Redmond are typically low compared to other King County municipalities.

Although flooding in Redmond tends to be shallow, water on roadways may cause significant road damage and limit access to important transportation routes or other services. While it is important to note that Redmond is not susceptible to large-scale severe flooding, any amount of water on a roadway in Redmond will create significant problems for the City, its residents, and those that are employed within its boundaries.

Redmond's building codes are based on a 100-year Sammamish River flood with a flow rate of 1,920 CFS (cubic feet per second). The resulting codes are stricter than the FEMA requirement, which is based on a 100-year Sammamish River flood flow rate of 1,535 CFS.⁶⁶ The building codes, in coordination with a well-monitored permitting process, regulate construction in the floodplain. Homeowners with frequently flooded crawl spaces or basements are prepared with water pumps to reduce water damages to their homes.

Should stormwater drains become clogged and overflow into a permeable surface area (such as low impact development practices like permeable pavement, rain gardens, or infiltration trenches; or lawns and other landscaped areas), there is risk of groundwater contamination. Within the City's drinking water wellhead protection zones, this risk has the potential consequence of requiring a very expensive cleanup or loss of up to 40% of the City's drinking water resource. The presence of hazardous materials within flooded areas increases the potential risk to the groundwater during flood events.

D. Frequency

Past Occurrences

In Redmond, the areas along the Bear Creek and Sammamish River trails flood more

⁶⁵ Bob Franklin, City of Redmond Floodplain Manager, informational interview, April 16, 2009.

⁶⁶ Bob Franklin, City of Redmond Floodplain Manager, informational interview, April 16, 2009.

frequently than other areas of the City. The United States Army Corps of Engineers' flood control project in the 1960s altered the natural path of Bear Creek and the Sammamish River to reduce flood frequency and severity in Redmond. In recent years, the City has experienced minor flooding almost annually. While such flooding may occur once or twice a winter season, groundwater seepage and stormwater drainage can be a consistent problem in rainy months. **Table 14, Past Occurrences of Flooding in Redmond**, provides specific information about the location and extent of historical flooding.

Past Occurrences of Flooding in Redmond			
Date	Location	Type	Extent
1/18/1986	Bear Creek	Riverine	Roadways over-topped, mobile home park flooded and evacuated
1/3/1997	Sammamish River	Riverine	Over-topping of pedestrian trail near NE 124th St.
1/2006	Bear Creek	Riverine	Reached capacity but did not over-top. Debris collected at bridges that crossed the creek's span.
12/2007	Sammamish River	Riverine	Over-bank inundation of river near NE 85th St, drainage system and storm water flooding at 150th Ave NE and in Overlake area
Chronic	Education Hill	Drainage	Localized flooding of small neighborhood
Chronic	82nd St between 169th Ave NE and 170th Ave NE	Drainage	Roadways within 1-block radius inundated
Chronic	Union Hil Rd. between 185th Ave NE and 196th Ave NE	Drainage	Nuisance flooding of existing street and parking areas of local businesses
Chronic	NE 40th St and Bel-Red road	Drainage	Localized nuisance flooding in intersection
Chronic	3060 and 3068 W Lk Sammamish Pkwy	Drainage	Nuisance ponding
Chronic	4850 162nd Ave NE, Marymoor Hills	Drainage and Seepage	Localized flooding; flooding of crawlspaces
Chronic	Willows Business Park 152nd	Drainage	Frequent nuisance flooding
Chronic	8350 164th Ave NE, 8450 165th Ave	Drainage	Frequent flooding of parking lot
Chronic	Willows Business Park 92nd St	Stream/Riverine/ Drainage	Nuisance flooding
Chronic	14001 NE 72nd St	Drainage	Localized flooding
Chronic	15000 NE 95th St	Drainage	Frequent nuisance flooding of parking lots
Chronic	156th Ave NE and NE 56th Way	Drainage	Ponding, Damage to paved surfaces
Chronic	162nd Ave NE and NE 57th St	Drainage	Ponding, Damage to paved surfaces
Chronic	140th Ave and NE 70th St	Drainage	Ponding, Damage to paved surfaces
Chronic	156th Ave NE and NE 65th Way	Drainage	Ponding, Damage to paved surfaces
Chronic	NW corner of Marymoor Park, South of 18000 NE 65th St	Drainage	Blocked access to loading docks and building entrances

(Table 14 continued on next page)

Past Occurrences of Flooding in Redmond (continued)			
Date	Location	Type	Extent
Chronic	2812 183rd Ave NE	Seepage	Groundwater flows year-round across sidewalk
Chronic	NE 48th St Conveyance	Drainage and Seepage	Capacity issues with groundwater under roadway
Chronic	Willows View Apartments	Drainage and Seepage	Water on sidewalks; damaged rockery
Chronic	17750 NE 21st St	Drainage	Damaged rockery
Chronic	176th Ave NE and NE 70th St	Drainage	Ponding, water over roadway
Chronic	S side of NE 24th, west of 179th Ave NE	Drainage	Blockage of culverts
Chronic	2000 West Lake Sammamish Pkwy	Drainage	Ponding on roadway
Chronic	9216 162nd Pl NE	Drainage	Flooding behind residential home
Chronic	Eastside of 146th just south of Old Redmond Rd	Drainage	Flooding of street; in 1993 flooding of homes
Chronic	177th Ave NE; Argyle Division	Drainage and Seepage	Surface erosion and flooding from pipe seepage
Chronic	City of Redmond Public Safety Building	Seepage	Flooding of below-ground parking garage
Chronic	Marriot Hotel	Seepage	Flooding of below-ground parking garage
Chronic	Sammamish River Trail and Bear Creek Trail	Riverine	Inundation of paved pedestrian trails making them impassable.

Table 14: Past Occurrences of Flooding in Redmond

Sources: City of Redmond Department of Natural Resources, "Stormwater Capital Improvement Program and City of Redmond," City of Redmond, <http://www.redmond.gov/insidecityhall/publicworks/stormwater/cipstormwater.asp> and City of Redmond Department of Natural Resources, "2009 Comprehensive Flood Hazard Management Plan".

Probability of Future Events

With climate change, more development in the watershed, increased stormwater runoff, and the introduction of more impermeable surfaces, the frequency of localized flooding events is likely to increase. Climate change research suggests an increase of extreme weather patterns with wetter winters characterized by increased precipitation and intensity.⁶⁷ The projected changes will increase the occurrence and severity of flooding events in Redmond.

6.3 Assessing Flood Vulnerabilities

6.3.1 Overview

Three large bodies of water coupled with a high water table pose a risk of flooding in Redmond. The presence of valuable buildings, infrastructure, natural environment and people make the City vulnerable to riverine and seepage flooding. Irregular weather and precipitation patterns resulting from climate change will also increase the City's vulnerability to floods.

⁶⁷ Climate Impacts Group: Joint Institute for the Study of the Atmosphere and Ocean, "Seasonal to Interannual Forecasts; Extreme Weather: Background," University of Washington, <http://cses.washington.edu/cig/fpt/exbackground.shtml>.

6.3.2 Profiling the Vulnerabilities

A. Man-made

Though riverine floods have been relatively mild in Redmond, flooding does cause damage to the built environment. **Map 18, City of Redmond Buildings Vulnerable to Flooding**, shows the flood depths and buildings located within the 100-year floodplain. There are 166 buildings located within the 100-year floodplain. Of these, 116 are single-family and 50 are multi-family units.⁶⁸ The mean appraised value of the buildings is \$2.1 million.⁶⁹ The City of Redmond does not have any repetitive loss structures.

Map 17, City of Redmond NFIP Claims and Holders, shows the buildings in the floodplain, NFIP holders and properties that have filed flood insurance claims. The claims range from \$0 to \$11,199 and average approximately \$2,600. Four of the five flood insurance claims have been related to seepage flooding outside of the floodplain.

Lakeside homes and docks are vulnerable to swelling or overtopping of the lake. As shown in **Map 18, City of Redmond Buildings Vulnerable to Flooding**, there are many lakeside homes within the floodplain.

B. Natural

The most significant threat posed by floods to the natural environment is the potential damage to fish and wildlife habitat. Channel alteration may affect wetlands and habitats in frequently flooded areas. A 25 to 50-year flood event in Bear Creek may result in significant damages to delicate riparian vegetation. The runoff associated with development and increased impervious surfaces has increased the occurrence of flooding. Runoff, bank erosion, sedimentation and siltation can alter the aquatic ecosystem and be potentially devastating to the fish habitat. While building in a floodplain may damage ecosystems, a flood induced by encroachment on the floodplain may further this damage by introducing toxins, debris, and significant amounts of sediment to the system. The flood's flow velocity may further increase losses to the ecosystem by removing riparian vegetation and salmon spawning areas.

Critical areas likely to be affected by flooding, including fish and wildlife habitat and wetlands, are shown in **Map 19, City of Redmond Natural Environment Vulnerable to Flooding**. Although these areas experience natural flooding, further development and climate change impacts may cause regular flooding events to have a greater impact on the natural environment. In addition to the Endangered Species Act's (ESA) designation of the Puget Sound Chinook salmon and bull trout as endangered species, Redmond is working hard to restore habitat in and near streams that will benefit species that have been listed, and other species, too.

⁶⁸ City of Redmond Department of GIS Services. 1999. RedmondGIS.DBO. Building GIS data layer.

⁶⁹ King County. Department of Assessments. Real Property Account. Assessor's <http://www.metrokc.gov/Assessor/download/download.asp>

C. Systems

Transportation, water systems, sewer systems and businesses located in the 100-year floodplain are vulnerable to flooding.

Sewer, stormwater and underground well water infrastructure are vulnerable to both riverine and stormwater and seepage floods. Since 40% of Redmond's water supply is provided by public wells, contamination of the wells would limit the availability of clean, fresh water in the City. Contamination of the groundwater would be difficult, if not impossible, to reverse. **Map 20, City of Redmond Water Supply and Sewer Infrastructure**, shows the location of sewer and water facilities that are located in the floodplain and critical areas.

Though rare, severe riverine flooding may shut down arterial parts of transportation systems. This could isolate neighborhoods or the entire City of Redmond. **Map 21, City of Redmond Vulnerable Transportation Networks**, shows transportation routes crossing the 100-year floodplain.

Transportation closures may limit businesses' abilities to operate normally. Businesses may be forced to close temporarily due to lack of patronage and/or employee absences. The disruption of delivery would also have negative impacts on the local economy. Small businesses are particularly vulnerable to temporary closures and property damage.

D. Populations

Hazard Specific

People with property located in the floodplain or within areas subject to seepage are vulnerable to flooding.

Isolated Populations

Transportation and road closures could isolate some neighborhoods. Due to the separation from downtown and major routes to the surrounding region, Education Hill may become isolated during an extreme flooding event. Services and supplies may be limited in the event of a flood.

Children

Flooding that occurs when children are separated from their families may result in limited resources and access to adequate transportation. Additionally, children may not know the proper precautions to take in the event of a flood.

Elderly

The elderly often have special medical or service needs that make isolation and road closures more serious problems for them compared to other vulnerable populations. **Map 22, City of Redmond Vulnerable Population Housing**, shows the location of retirement homes and senior housing. Three are located within or very near the floodplain. Two are located in the Northeast, which may become isolated.

Limited English Speakers

Residents with limited English proficiency may not have immediate access to emergency announcements, unless translation is provided. Additionally, language barriers may limit access to mitigation opportunities and opportunities to provide input in the Comprehensive Flood Hazard Management Plan. **Map 23, City of Redmond Limited English Language Capability in Floodplain**, shows the areas of limited English speakers.

Low-income Residents

Lack of adequate financial resources increases the vulnerability of low-income residents. This population may not be able to participate in costly mitigation efforts. Renters and mobile home owners may be limited to owner-initiated mitigation efforts. There is only one designated affordable housing⁷⁰ building within the floodplain. **Map 22, City of Redmond Vulnerable Population Housing**, shows the location of affordable housing relative to the floodplain. Households with limited income may face an additional hardship responding to flood damages or income losses.

6.3.3 Analyzing Development Trends

The City's Planning Department is currently focusing on an economic development plan to promote and advertise the existing businesses in the downtown area.⁷¹ One of the City's main goals in its Comprehensive Plan is to support vibrant concentrations of retail, office, service, residential, and recreational activity in the Downtown and Overlake neighborhoods. However, additional development in the floodplain will increase the City's vulnerabilities to flooding. While centralized, compact development will provide additional local services, dense development in the floodplain will change the impacts of flooding. Increasing the number of people and structures in the floodplain will increase the potential damages. Additionally, development will decrease permeability and thus increase runoff and the corresponding impacts.

6.4 Scenario

After three consistent days of rain, several reports of backed-up storm drains throughout the city are called in at 3 p.m. Thursday, April 10th. By that evening, ponding of one to two feet deep has occurred throughout the Sammamish valley. Saturated soils have slowed drainage and caused additional localized flooding from seepage. Twelve homes and three businesses in the floodplain have reported damage from the floodwaters. Three homes outside the floodplain have reported groundwater seepage in crawlspaces.

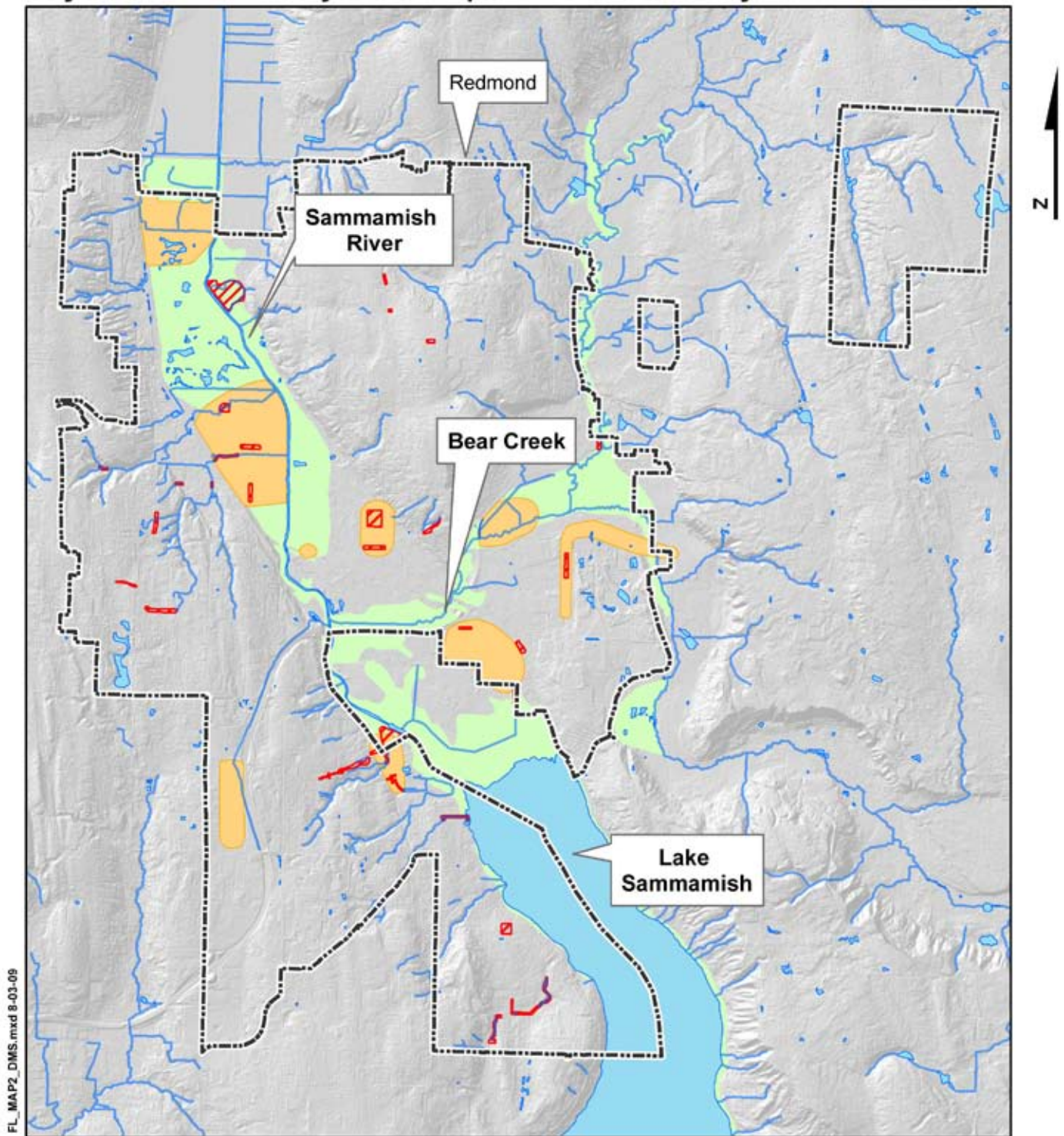
Although lakeside homes are cautious of flooding, landslides pose a greater threat. The saturated banks of Lake Sammamish are showing signs of movement and two homes have been evacuated.

⁷⁰ Buildings that have income restrictions are the only "affordable housing" units considered in this report. Information is limited for market-rate affordable housing.




⁷¹ Jim Roberts, City of Redmond Planning Department, informational interview, 2009.

Roads are extremely wet and flooding on West Lake Sammamish Parkway is limiting traffic to one lane. Businesses are operating on a limited basis due to the difficulty of traversing the valley. Several companies have encouraged employees to work from home. Weather reports predict continued rain.

City of Redmond 100-year Floodplain and Chronically Flooded Areas



Source: King County

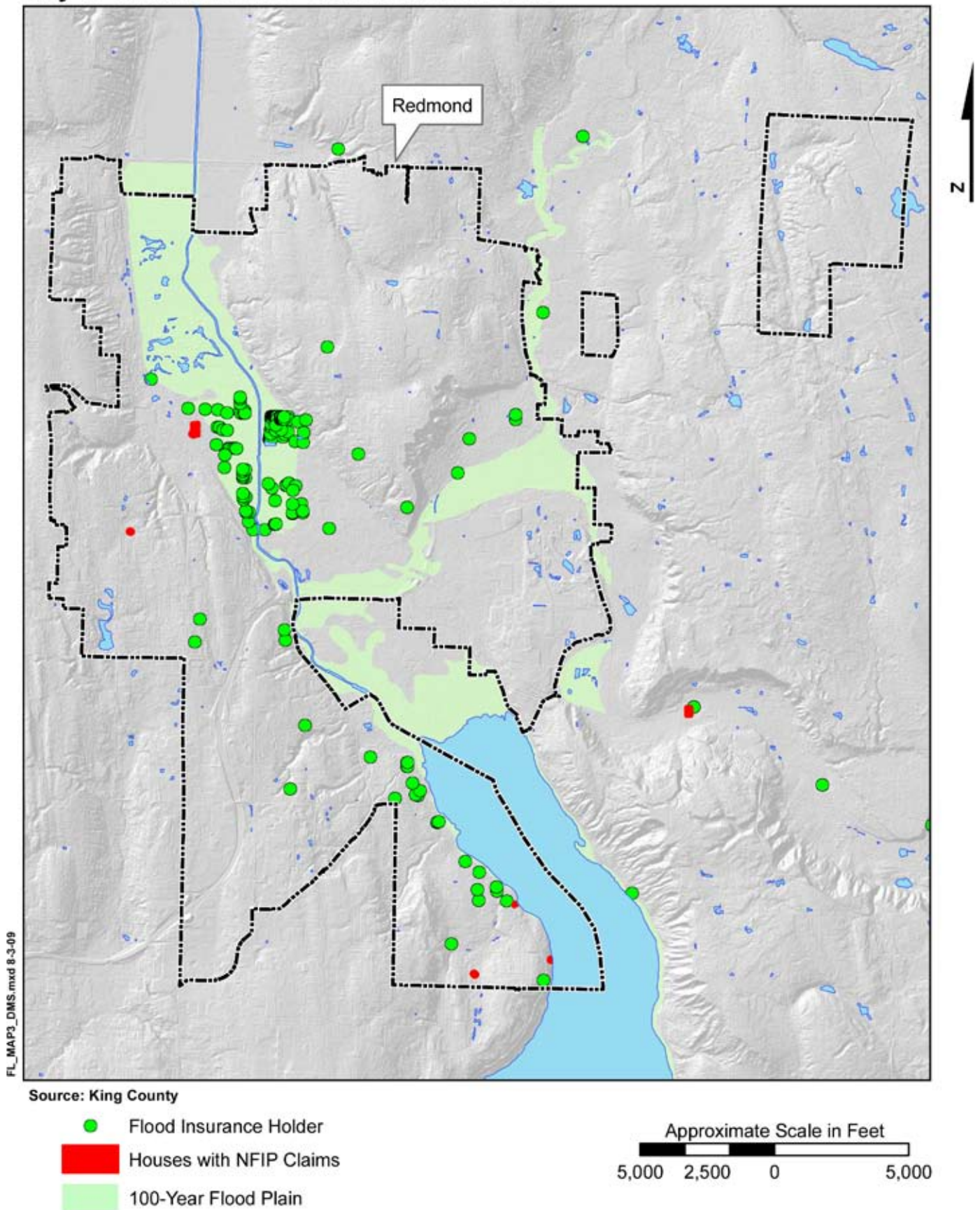
-  Flood Projects Identified
-  Chronic Flooding Areas
-  100 Year floodplain

Approximate Scale in Feet

5,000 2,500 0 5,000

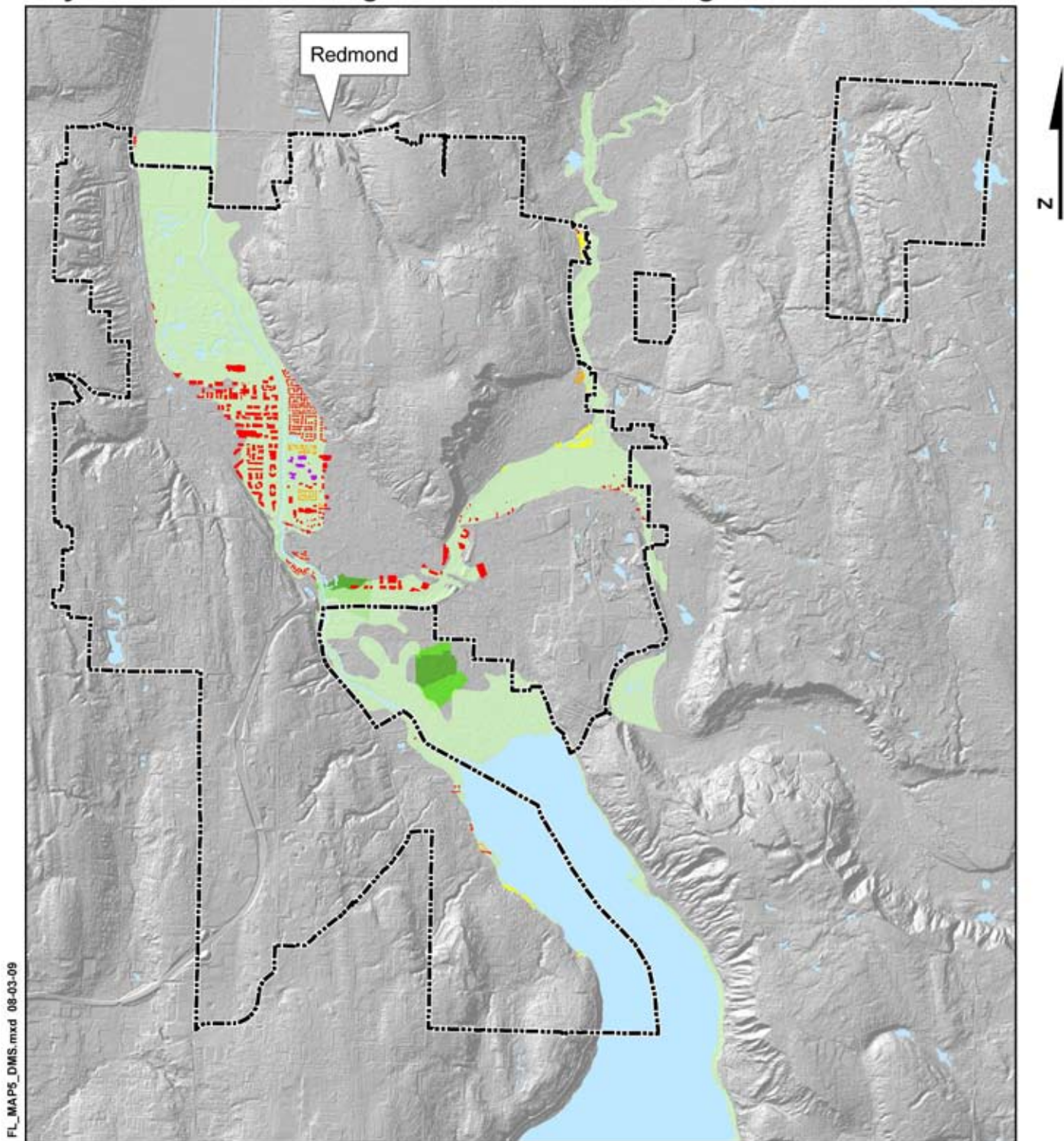
Map 16: City of Redmond 100-Year Floodplain and Chronically Flooded Areas
Hazard Identification and Risk Assessment

City of Redmond NFIP Claims and Holders



Map 17: City of Redmond NFIP Claims and Holders

City of Redmond Buildings Vulnerable to Flooding

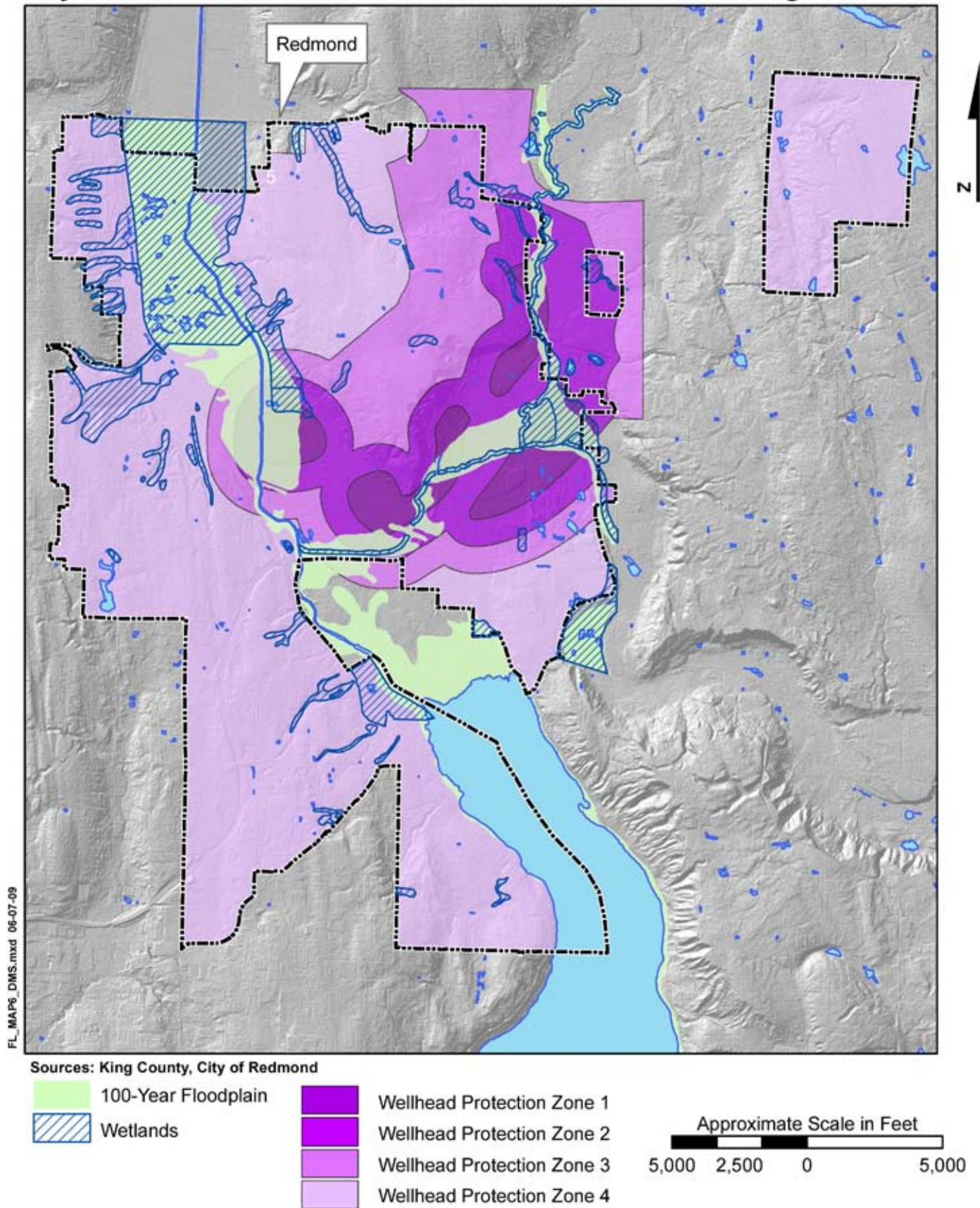


- 1-Foot Flood Depth
- 2-Foot Flood Depth
- 3-Foot Flood Depth

- Commercial
- Multi-Family
- Public Buildings
- Single Family

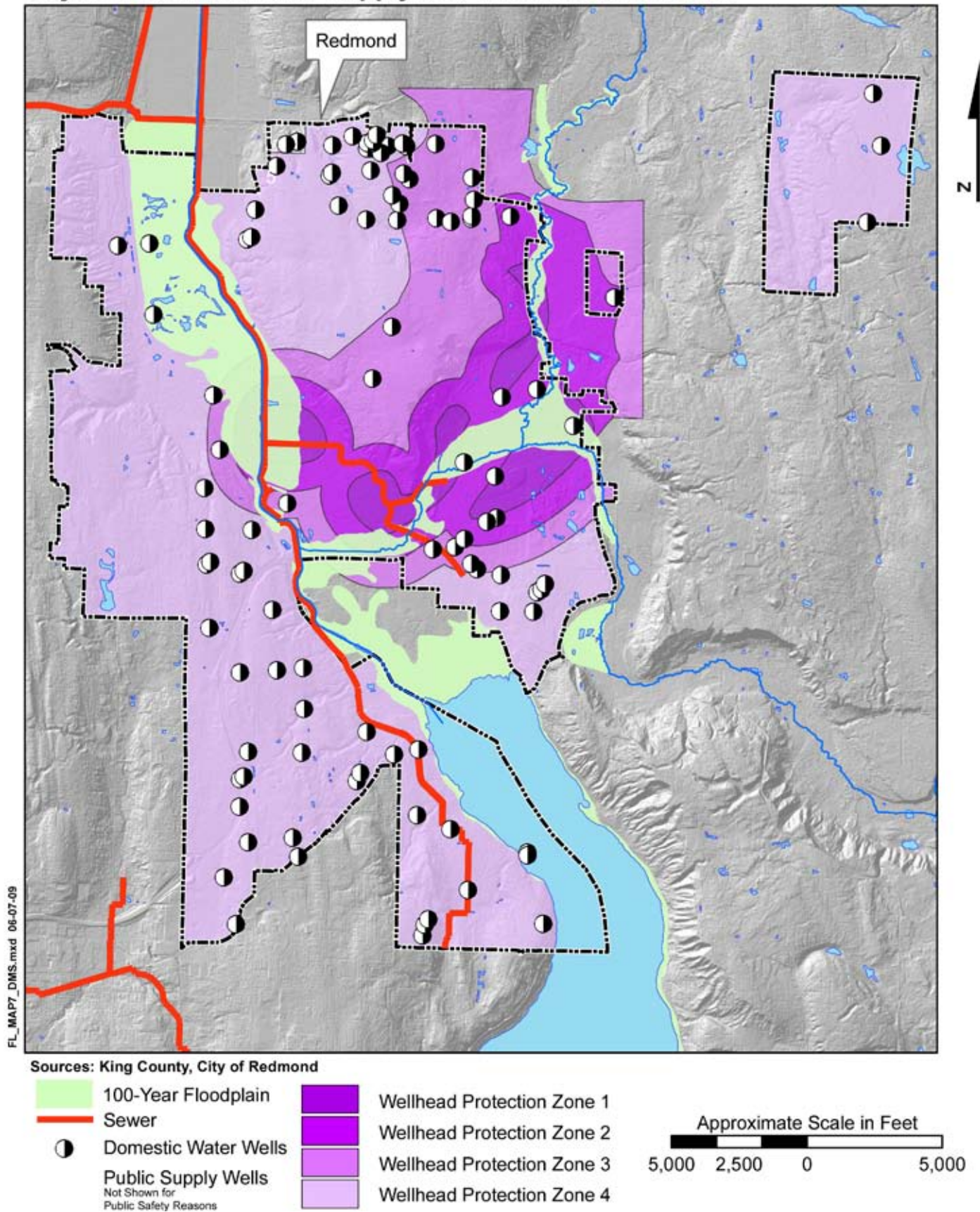
Map 18: City of Redmond Buildings Vulnerable to Flooding

City of Redmond Natural Environment Vulnerable to Flooding



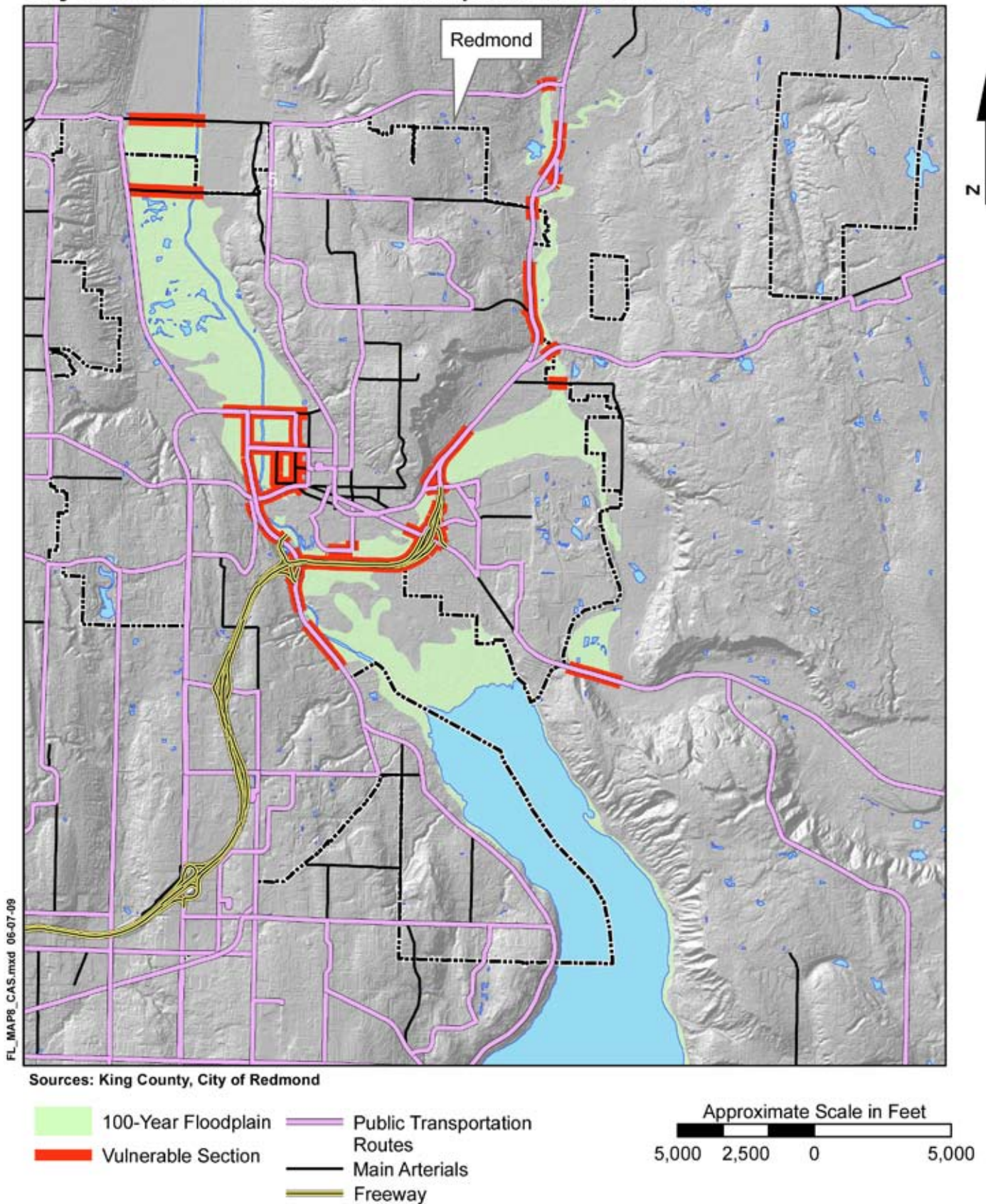
Map 19: City of Redmond Natural Environment Vulnerable to Flooding
 Hazard Identification and Risk Assessment

City of Redmond Water Supply and Sewer Infrastructure



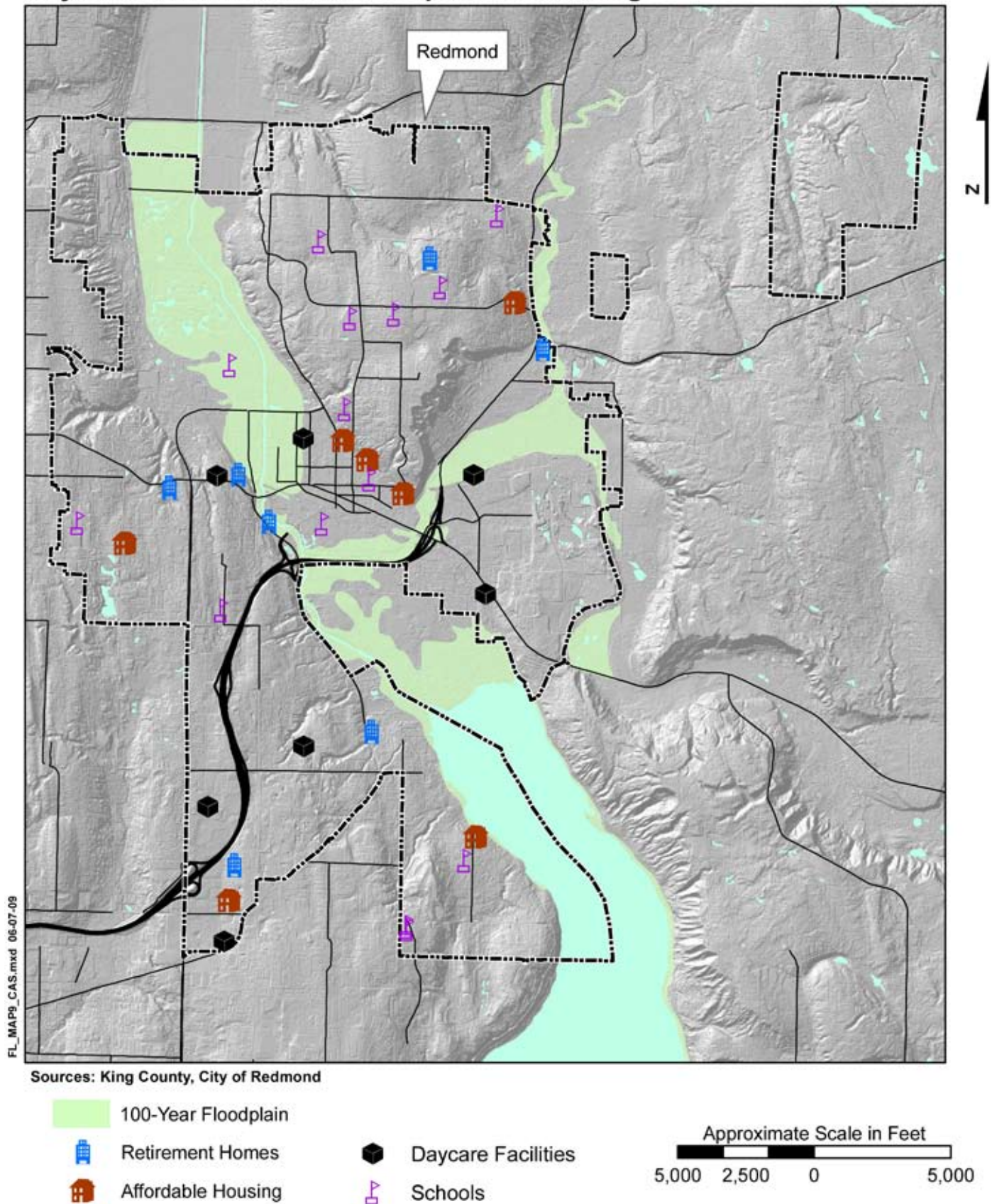
Map 20: City of Redmond Water Supply and Sewer Infrastructure
 Hazard Identification and Risk Assessment

City of Redmond Vulnerable Transportation Networks

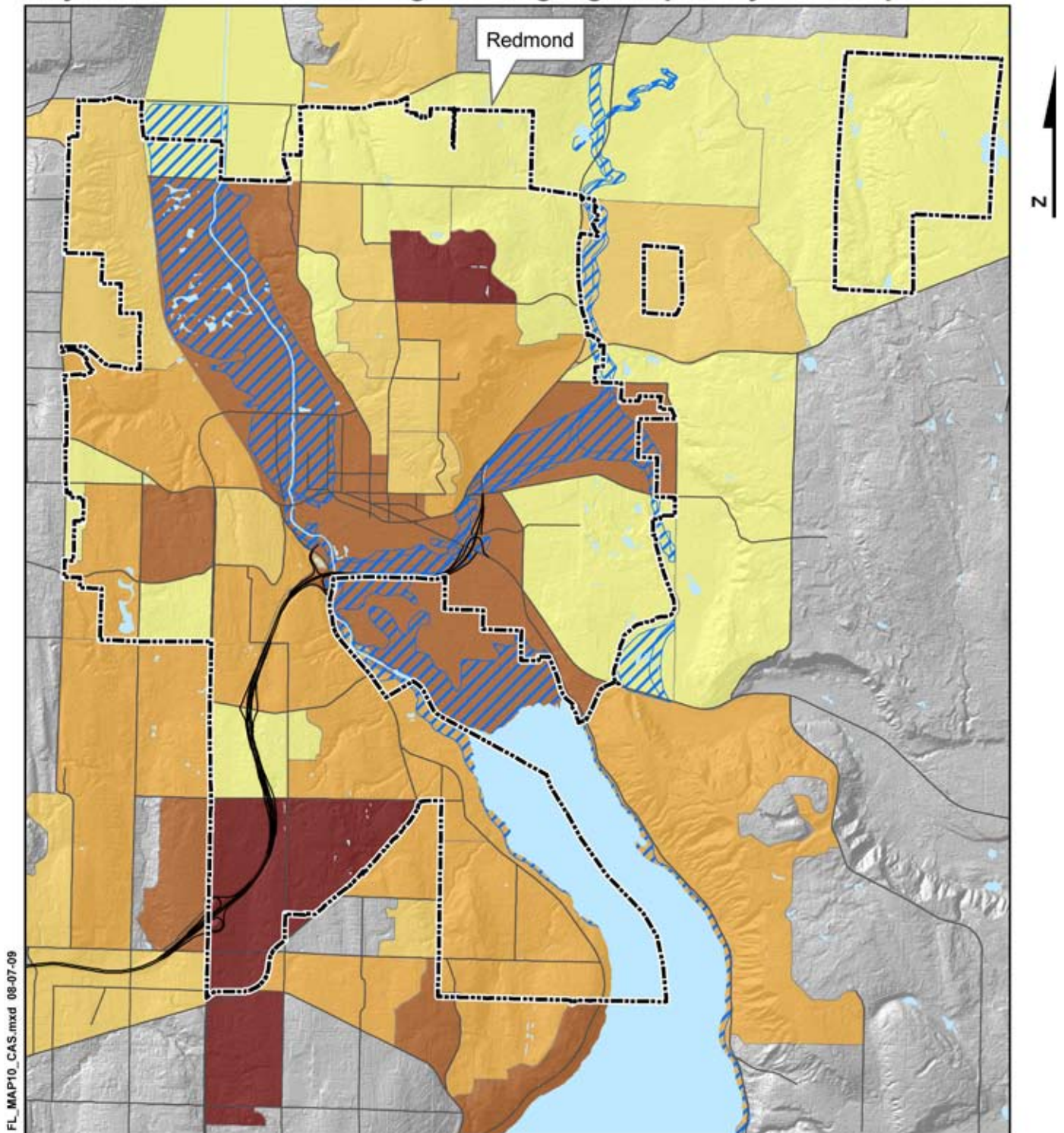


Map 21: City of Redmond Vulnerable Transportation Networks
 Hazard Identification and Risk Assessment

City of Redmond Vulnerable Population Housing

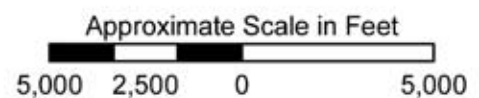
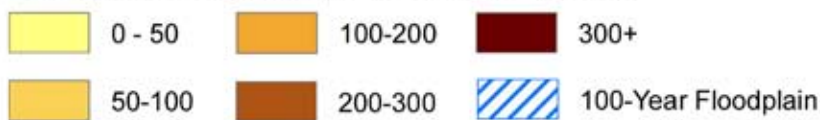


City of Redmond Limited English Language Capability in Floodplain



Sources: King County, US Census

Number of People with Limited English Language



Map 23: City of Redmond Limited English Language Capability in Floodplain

[This page intentionally left blank]